Comparison of photographic and visual surveys of ringed seals in western Hudson Bay

Brent G. Young and Steven H. Ferguson

Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB R3T 2N6

2016

Canadian Technical Report of
Fisheries and Aquatic Sciences 3153

Pêches et Océans Canada
Fisheries and Oceans Canada

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of Fisheries and Oceans Canada, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in the data base *Aquatic Sciences and Fisheries Abstracts*.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page.

Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques de Pêches et Océans Canada, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications à part entière. Le titre exact figure au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la base de données *Résumés des sciences aquatiques et halieutiques*.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre.

Les numéros 1 à 456 de cette série ont été publiés à titre de Rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de Rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Canadian Technical Report of
Fisheries and Aquatic Sciences 3153

2016

Comparison of photographic and visual surveys of ringed seals in western Hudson Bay

Brent G. Young and Steven H. Ferguson

Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB R3T 2N6

© Her Majesty the Queen in Right of Canada, 2016
Cat. No. Fs 97-6/3153E-PDF ISBN 978-0-660-04301-2 ISSN 1488-5379

Correct citation for this publication:

Young, B.G. and Ferguson, S.H. 2016. Comparison of photographic and visual surveys of ringed seals in western Hudson Bay. Can. Tech. Rep. Fish. Aquat. Sci. 3153: iii + 11 p.

ABSTRACT

Young, B.G. and Ferguson, S.H. 2016. Comparison of photographic and visual surveys of ringed seals in western Hudson Bay. Can. Tech. Rep. Fish. Aquat. Sci. 3153: iii + 11 p.

To improve estimates of wildlife population abundance, photographic survey techniques are being incorporated into traditional survey methods at an increasing rate. Technological advances allow the capture of high-resolution digital images from a survey platform in a straightforward and cost-effective way. However, before photography can be put into widespread use for large-scale surveys, it is important to understand how photographic survey results compare to those of traditional visual methods. This report presents the findings of aerial surveys of ringed seals in western Hudson Bay, comparing density estimates obtained using visual methods and photographic methods. Although the photographic survey provided higher density estimates more often than the visual survey, it is unclear which method provides more accurate results. The advantages and disadvantages of each method are discussed.

RÉSUMÉ

Young, B.G. and Ferguson, S.H. 2016. Comparaison entre les résultats des survols aériens photographiques et visuels de phoques annelés dans l'ouest de la baie d'Hudson. Can. Tech. Rep. Fish. Aquat. Sci. 3153: iii + 11 p.

Dans le but d'améliorer les estimations d'abondance d'animaux sauvages, les techniques de survol aérien par photographie sont incorporées aux techniques plus traditionnelles de dénombrement. De nouvelles avancées technologiques permettent de prendre des images numériques à haute définition, lors de survols aériens, assez facilement et de façon rentable. Par contre, il est important de comparer les résultats des survols par photographie avec ceux des méthodes d'observation visuelle traditionnelles avant d'appliquer ces nouvelles méthodes à grande échelle. Ce rapport présente les résultats d'un survol aérien des phoques annelés de l'ouest de la baie d'Hudson, et compare les densités obtenues par les méthodes traditionnelles d'observation visuelle et par photographie aérienne. La méthode par photographie aérienne donne des densités de phoques plus élevées. Néanmoins, il est difficile de déterminer quelle méthode donne une meilleure précision. En analysant le chevauchement entre les photos, nous avons estimé que 8 ou 9 % des phoques seraient absents des observations visuelles traditionnelles parce que ces derniers plongent sous l'eau à l'approche de l'avion. Toutefois, cette estimation pourrait être biaisée de façon positive. Finalement, nous discutons des avantages et inconvénients de chaque méthode.

INTRODUCTION

The use of photographs for surveying wildlife populations is becoming increasingly popular as it offers a number of advantages over visual techniques. However, for many species, if photography is to become a practical way of conducting aerial surveys, a number of challenges must be overcome. Visual aerial surveys of ringed seals (*Pusa hispida*) in western Hudson Bay have been conducted since 1995 (Lunn et al., 1997, Chambellant et al., 2012, Young et al., 2015) and, in recent years, surveys have included a photographic component as a means of attempting to improve ringed seal density and abundance estimation.

Surveys are flown in late May and early June, to coincide with the peak of the molting season, when ringed seals are hauled out on the sea ice and are available to be counted via aerial surveys. During the molt, ringed seals have been found to spend approximately 55% of their time out of the water (Kelly et al., 2010), while some individuals have been observed to be hauled out for more than 40 consecutive hours (Smith and Hammill, 1981). Although variable by geographic region, the molting season lasts from approximately mid-May to mid-July, with the peak occurring in June (McLaren, 1958; Finley, 1979; Smith and Hammill, 1981; Kelly et al., 2010). Due to the lower latitude and relatively earlier ice breakup in western Hudson Bay, the peak haul-out period likely occurs earlier than other areas, roughly late May to early June.

For photographic methods to become a practical way to conduct large scale aerial surveys of ringed seals, a number of challenges must be overcome. The purpose of this report is to summarize the analysis of aerial photographs collected during western Hudson Bay ringed seal surveys in 2009 and 2010, and to compare density estimates obtained using photographic and visual methods. The information contained in this report will be important in the development of photographic survey methods for the practical application of conducting large scale surveys of ringed seals, and to improve density and abundance estimation over the visual methods that are currently used.

METHODS

Survey Methods

The survey design consisted of ten transects, spaced 15' of latitude apart, oriented east to west, and bounded by the Hudson Bay shoreline in the west, the 89°W longitude line in the east, the community of Churchill, MB in the south, and the community of Arviat, NU in the north (Figure 1). The study area was initially defined by Lunn et al. (1997) and coincides with the winter and spring hunting habitat of the western Hudson Bay polar

bear (*Ursus maritimus*) population, as determined by satellite telemetry data (Stirling and Derocher, 1993).

Surveys were flown in a Cessna 337 Skymaster at a target altitude of 152m and speed of 260km/h. Observers seated in the rear of the aircraft conducted a systematic strip-transect visual survey, while a Canon EOS 5D Mark II digital SLR camera with a 24mm lens, mounted in a camera pod below the aircraft, was used to collect digital photographs. The camera was tilted forward, at an angle of 20°, to capture the area directly below and slightly ahead of the aircraft (Figure 2). Controlled and powered by a laptop computer and power source inside the aircraft, the camera captured an image every 1.3 seconds, providing continuous coverage along the track line. The amount of overlap between consecutive photos was approximately 30%, however, this varied with changes in speed and altitude. Camera exposure was adjusted manually before the start of each transect, however, changes in cloud cover and lighting that occurred over the course of the transect sometimes resulted in photographs being either underexposed or overexposed. Detailed methods used in the visual survey are described in Lunn et al. (1997), Chambellant et al. (2012), and Young et al. (2015).

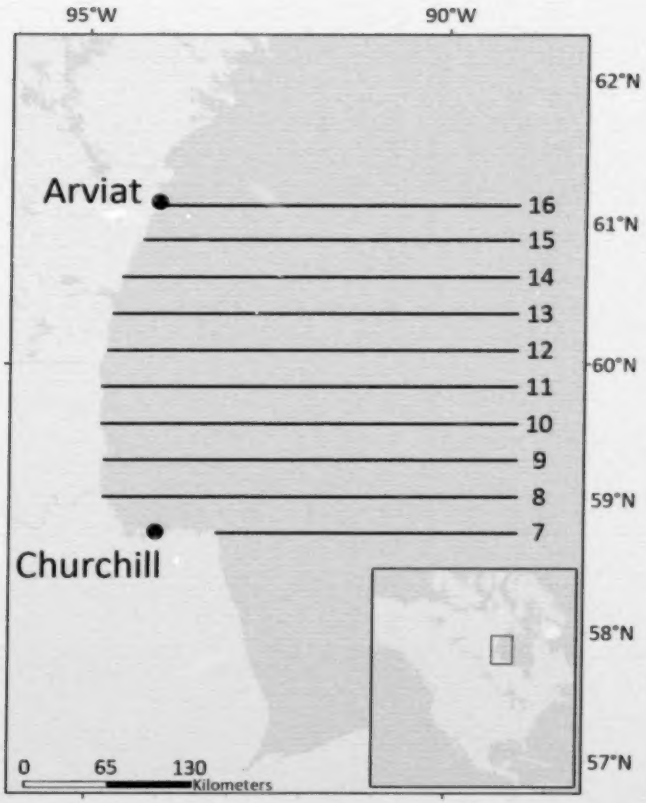

Figure 1. Transects flown during aerial surveys of ringed seals in western Hudson Bay, 2009 and 2010.

Analysis of aerial survey photographs

Photos were viewed at 50% of their actual size in *Adobe Photoshop 7*, by a single observer. When a potential observation was seen, the photo was enlarged to at least 100% of the actual size (usually larger for potential seals and breathing holes) and when necessary, the brightness and contrast of the image was adjusted to enhance the detail of the image. Observations of ringed seals, bearded seals (*Erignathus barbatus*), beluga whales (*Delphinapterus leucas*), polar bears, seal holes, and polar bear tracks were recorded. For each observation, photo number, group size, pixel coordinates, and certainty scores were recorded. Certainty scores ranged from 0 (absolutely uncertain) to 2 (absolutely certain). In addition, if an observation included evidence of polar bear/seal interactions, for example, polar bear tracks leading to a seal hole, it was noted. The forward facing angle of the camera provided overlap between photos and, when the

same seals were visible in consecutive photos, allowed us to determine how often seals were diving in response to the aircraft.

All photos collected during the 2009 survey and a subset of the photos from the 2010 survey were analysed by a single observer. For 2010, all photos over land fast ice and every fifth photo over the rest of the study area were analysed. The first photo analysed on each transect was selected at random. Whenever seals were observed, the previous and next photos were also checked to determine if the same seals were present in consecutive photos, to assess if there was a diving response to the aircraft.

To assess the level of exposure, the histograms of at least 5 photographs from each transect were examined and the mean tonal value of the pixels was used as an indication of changes in exposure levels along the length of each transect and to determine a mean exposure level for each transect. Using the RGB 24 bit color scale, tonal values range from 0 (pure black) to 255 (pure white). For consistency, only photographs of snow-covered ice, with no open water, were used for analysis of exposure levels. Photos were selected from along the length of the entire transect to achieve full representation of the range of lighting conditions experienced on a given transect.

Calculation of photographic area

The dimensions of the area covered in each photograph, represented by *A*, *B*, and *C* in Figure 2, were determined following Grenzdorffer et al. (2008):

$$A = h \times \tan(\alpha + \beta) - h \times \tan(\alpha - \beta)$$

$$B = \frac{h \times cos\beta}{f \times cos(\alpha - \beta)} \times s_h$$

$$C = \frac{h \times cos\beta}{f \times \cos(\alpha + \beta)} \times s_h$$

where h is the altitude of the aircraft (152m), α is the angle at which the camera is tilted forward (20°), β is half of the vertical angle of view of the lens (26.5°), *f* is the focal length of the lens (24mm), and s_h is the size of the camera sensor in the horizontal dimension (35.8mm). β, half of the vertical angle of view, was calculated using:

$$\beta = arctan\left(\frac{s_v}{2f}\right)$$

where s_v is the size of the camera sensor in the vertical dimension (23.9mm).

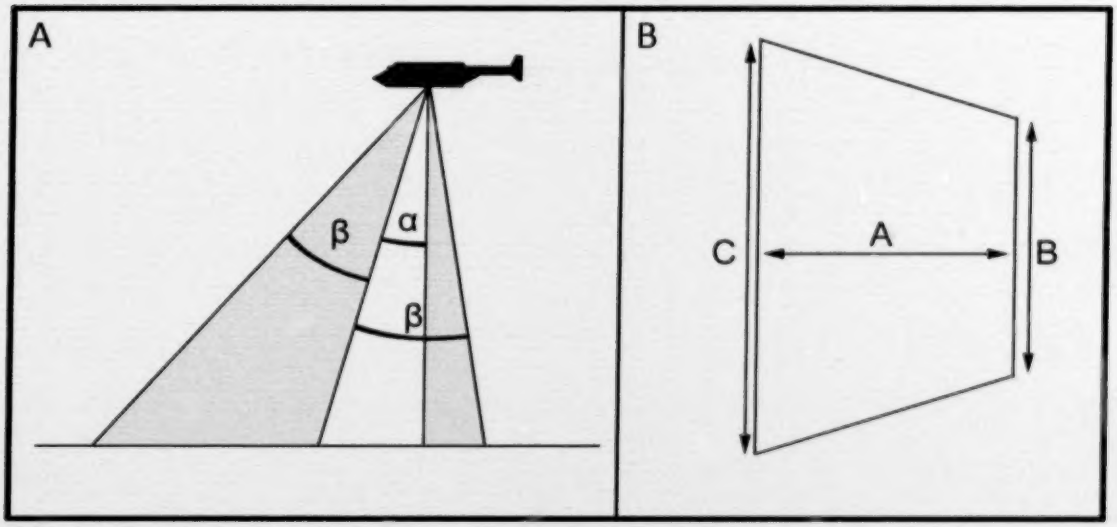

Figure 2. The angle of the camera (α) and half of the vertical angle of view of the lens (β) were used to calculate the dimensions (A=178m, B=205m, C=295m) of the area covered by each photograph taken during aerial surveys of ringed seals in western Hudson Bay.

Calculation of density estimates

The density of ringed seals per km^2, $\widehat{D}$, was estimated for each transect individually and for each year, using the standard ratio estimate (Buckland et al., 2001):

$$\widehat{D} = \sum_{i=1}^{k} n_i / \omega \sum_{i=1}^{k} l_i$$

Where k is the number of transects flown, n_i is the number of ringed seals counted on the ith transect, ω is the width of the strip, and l_i is the length of the ith transect.

Following Kingsley and Smith (1981), the variance of density, $\sigma^2(\widehat{D})$, was determined by:

$$\sigma^2(\widehat{D}) = k \times \frac{\sum_{i=1}^{k-1}(d_i - d_{i+1})^2}{2(k-1) \times (\omega \sum_{i=1}^{k} l_i)^2}$$

where

$$d_i = n_i - \widehat{D} \times \omega l_i$$

Density estimates were calculated for both photographic and visual surveys, then compared by determining the percent difference between photographic and visual density estimates for each transect:

$$Percent\ Difference = \frac{\hat{D}_p - \hat{D}_v}{(\hat{D}_p + \hat{D}_v)/2} \times 100$$

Where $\hat{D}_p$ and $\hat{D}_v$ are the density estimates obtained from photographic and visual surveys, respectively. Density estimates for visual surveys were determined using only the transects (or partial transects) for which there was photographic coverage. Density estimates for photographic surveys were determined using all photographs collected during the 2009 survey, and every fifth photograph collected during the 2010 survey.

RESULTS

In 2009, due to technical difficulties and equipment malfunction, photographs were only collected from transects 7 and 8, flown on the 2nd of June. In 2010, the survey was flown between the 5th and the 9th of June and photographs were collected from all transects except for transects 9 and 15, and from a portion of transects 10 and 16. All of the photos (3899) from the 2009 survey and 21% of the photos (4869 out of 23,129) from the 2010 survey were analysed by a single observer (Table 1).

Table 1. Observations from the analysis of aerial survey photographs taken over western Hudson Bay in 2009 and 2010. For 2009, observations are from all available photographs (n=3899), while for 2010, observations are from all photographs over land fast ice and every fifth photograph over the rest of the study area (n=4869).

	2009			2010								
Observation	7	8	Total	7	8	10	11	12	13	14	16	Total
Ringed Seals	31	38	69	33	53	4	24	41	36	5	10	206
Bearded Seals	2	1	3	2	4	0	1	2	2	1	1	13
Beluga Whales	0	6	6	0	0	1	0	0	0	0	0	1
Seal Holes	38	57	95	20	33	3	25	37	17	38	19	192
Polar Bear Tracks	238	324	562	19	44	40	29	51	20	15	14	232

The dimensions of the area covered in each photograph were 295m on the longest edge perpendicular to the track line (top edge of photograph), 205m on the shortest edge perpendicular to the track line (bottom edge of photograph), and 178m from the top edge to the bottom edge of the photograph, parallel to the track line (Figure 2).

In general, observations obtained from photographic and visual surveys resulted in different estimates of ringed seal density (Table 2). In most cases (2009 transects 7 and 8, and 2010 transects 7, 8, 11, and 13) photographic surveys estimated higher densities than visual surveys. However, in some cases, density estimates from photographic and visual surveys were approximately the same (2010 transects 12 and 16), or visual surveys estimated higher densities than photographic surveys (2010 transects 10 and 14).

Table 2. Comparison of ringed seal observations and density estimates obtained from visual and photographic aerial surveys of western Hudson Bay. Percent difference represents the difference between ringed seal density estimates obtained from photographic and visual surveys. Photo exposure level is the mean tonal value determined from photographs taken over snow-covered ice, using a 24 bit RGB color scale, where 0 represents pure black, and 255 represents pure white.

	Ringed Seals Observed		Average Group Size		Density Estimate (seals/km^2)		Percent Difference	Photo Exposure Level
Transect	Visual	Photos	Visual	Photos	Visual	Photos		
2009								
7	35	31	1.75	1.41	0.33	0.93	95.68	122.05
8	22	38	1.69	1.5	0.13	0.71	138.72	135.09
All Transects	57	69	1.73	1.46	0.21 ± 0.09	0.79 ± 0.10	116.00	128.57
2010								
7	217	32	1.96	1.39	1.12	1.44	24.59	194.51
8	276	53	2.27	1.96	1.06	1.75	49.74	185.17
10	67	4	1.97	1.33	0.62	0.42	-37.65	152.72
11	135	24	1.35	1.26	0.52	0.80	42.57	155.50
12	196	23	1.62	1.64	0.76	0.79	3.38	153.92
13	209	31	1.43	1.11	0.83	1.08	26.70	202.83
14	124	5	1.43	1.25	0.50	0.16	-101.78	181.14
16	77	9	1.33	1.13	0.34	0.35	2.80	156.96
All Transects	1301	181	1.67	1.44	0.72 ± 0.06	0.88 ± 0.17	20.00	172.84

Analysis of overlapping photographs indicated that in 2009 and 2010, respectively, 9% (5 out of 55) and 8% (14 out of 179) of ringed seals hauled out on the ice in the first photograph were no longer visible on the ice in the subsequent photograph. Polar bear/seal interactions, in the form of polar bear tracks leading to seal holes, were evident at 32% (30 out of 95) of identified seal holes in 2009, and at 6% (11 out of 192) of seal holes in 2010.

DISCUSSION

The results of this study might suggest that the photographic methods used to survey ringed seals in western Hudson Bay provide higher density estimates than visual surveys. However, this is not always the case, as some transects had photographic density estimates that were lower than or about equal to visual density estimates. This inconsistency doesn't appear to be related to the group size of observations (a few large aggregations detected by observers could result in artificially high density estimates for a given transect), or to the exposure level of the photographs on the transects in question (photos that are severely over or under exposed would make detection of seals more difficult). On each of the transects in which photo density estimates were less than or about equal to visual density estimates, the number of ringed seals detected in the photographs was relatively small, and each of these transects was from the 2010 survey, in which every fifth photograph was analysed. It is possible that the subset of photographs analysed was too small, and that increasing the proportion of analysed photographs would result in more seal detections and more consistent results.

The percentage of seals diving in response to the aircraft is similar to findings from a study conducted in Svalbard, which found that 6% of ringed seals dove in response to a fixed wing aircraft flying at an altitude of 150m (Born et al., 1999). Born et al. (1999) noted that the seals dove within an area that was less than about 600m in front of the aircraft. Our analysis was limited to detecting a diving response within an area of less than 200m in front of the aircraft, so the actual proportion of seals which dove in response to the aircraft in our study, may actually be higher than the 8 or 9% estimated by our analysis. An understanding of how seals respond to the survey aircraft is important because it will allow visual density estimates to be adjusted to account for seals which dive before the aircraft reaches them, making themselves unavailable to be counted by visual observers.

The use of photographs to survey marine mammals has both advantages and disadvantages when compared to traditional visual survey methods. Perhaps the most obvious advantage is that photographs can be studied in-depth by multiple observers, reducing the number of missed observations and enhancing the ability to correctly determine the species and group size of an observation. However, in-depth analysis of each photograph requires a significant time commitment, making analysis of photographs both tedious and time consuming. Efforts to analyse large volumes of photos in a timely manner include the use of specialized software to automate the process of identifying animals in photographs, and citizen science, in which a large number of volunteers use web based applications to identify animals in the photographs. Both automated software and citizen science methods are currently in development, and have not yet proven to be a practical means for analysis of aerial survey photographs.

One of the other disadvantages to the use of photographs is that the surveyed area is much smaller than it is with visual observation. In the case of this study, the strip width covered by photographs was 250m, compared to a strip width of 800m covered by the two visual observers. However, if all the photos are analysed, all of the seals within the 250m photographic strip should be detected, whereas a significant proportion of the seals within the 800m visual survey strip will not be seen by observers. There is a clear trade-off between the two methods, and further study is required to determine which methods provide better estimates. Similarly, studies like this will help to identify problems with current photographic methods, and offer recommendations for improvements to photographic survey techniques, eventually leading to methods that will provide a clear advantage over traditional visual surveys.

For photographic surveys of seals in western Hudson Bay, two areas where improvements could be made are in increasing the strip width covered by the photographs, and decreasing the number of photographs to be analysed and/or increasing the speed and efficiency at which photographs can be analysed. One way in which to increase the strip width while decreasing the number of photographs to be analysed is by using a higher resolution camera and flying at a higher altitude. Flying at a higher altitude would increase the size of the photographic footprint, increasing strip width and reducing the number of photos necessary to obtain complete photographic coverage along the track line. However, the resolution of the camera would have to be high enough to allow for the detection of seals in the photographs. Test flights at various altitudes would be necessary to determine what altitude would continue to allow for detection of seals in photographs. Alternatively, keeping survey altitude unchanged, two cameras, tilted at oblique angles could be used to increase the photographic strip width; however, this would result in twice as many photographs to be analysed. In the absence of a fast, efficient way to analyse photos, this option is likely not a practical solution.

REFERENCES

Born, E.W., Riget, F.F., Dietz, R., and Andriashek, D. 1999. Escape responses of hauled out ringed seals (*Phoca hispida*) to aircraft disturbance. Polar Biology 21(3):171-178.

Buckland, S., Anderson, D., Burnham, K., Laake, J., Borchers, D., and Thomas, L. 2001. Introduction to distance sampling: estimating abundance of wildlife populations. Oxford University Press.

Chambellant, M., Lunn, N.J., and Ferguson, S.H. 2012. Temporal variation in distribution and density of ice-obligated seals in western Hudson Bay, Canada. Polar Biology 35(7):1105-1117.

Finley, K.J. 1979. Haul-out behaviour and densities of ringed seals (*Phoca hispida*) in the Barrow Strait area, NWT. Canadian Journal of Zoology 57(10):1985-1997.

Grenzdorffer, G.J., Guretzki, M., and Friedlander, I. 2008. Photogrammetric imag acquisition and image analysis of oblique imagery. The Photogrammetric Record 23(124):372-386.

Kelly, B.P., Badajos, O.H., Kunnasranta, M., Moran, J.R., Martinez-Bakker, M., Wartzok, D., and Boveng, P.L. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33:1095-1109.

Kingsley, M., and Smith, G. 1981. Analysis of data arising from systematic transect surveys. In Symposium on Census and Inventory Methods for Populations and Habitats. Edited by F.L. Miller and A, Gunn. Contribution No. 217. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho. pp. 40-48.

Lunn, N., Stirling, I., and Nowicki, S. 1997. Distribution and abundance of ringed (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) in western Hudson Bay. Canadian Journal of Fisheries and Aquatic Sciences 54(4):914-921.

McLaren, I.A. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian Arctic. Bulletin of the Fisheries Research Board of Canada 118. 97 p.

Smith, T., and Hammill, M. 1981. Ecology of ringed seal, *Phoca hispida*, in its fast ice breeding habitat. Canadian Journal of Zoology 59:966-981.

Stirling, I., and Derocher, A.E. 1993. Possible impacts of climatic warming on polar bears. Arctic 46(3):240-245.

Young, B.G., Ferguson, S.H., and Lunn, N.J. 2015. Variation in ringed seal density and abundance in western Hudson Bay estimated from aerial surveys, 1995 to 2013. Arctic 68(3):301-309.